

CONTRIBUTION OF THE "HANGED" DIAGRAMS INTO THE REACTION $np \rightarrow np\pi^+\pi^-$

A.P. Jerusalemov

JINR, Dubna, Moscow region, 141980, Russia

Abstract

The contribution of "hanged" diagrams into the reaction $np \rightarrow np\pi^+\pi^-$ was considered. It was shown that taking into account of these diagrams permits to get better description of the effective mass spectrum of $\pi^+\pi^-$ -combinations.

In paper[1] it was studied the mechanism of the reaction $np \rightarrow np\pi^+\pi^-$ at intermediate energies ($1.73 < P_0 < 5.2 \text{ GeV}/c$). It was shown that the main contribution made the diagrams with exchange by reggeized pi-meson (Fig.5 and Fig.7 in [1]). Moreover it is necessary to take into account also the diagrams of one-baryon exchange (Fig.10 in [1]) at energies below 3 GeV. A good description of the characteristics of the reaction $np \rightarrow np\pi^+\pi^-$ was obtained at the considered energy region. So-called "hanged" diagrams of pi-meson exchange (similar to shown in Fig.1) was not considered because their contribution did not exceed 2% at $P_0 = 5.20 \text{ GeV}/c$.

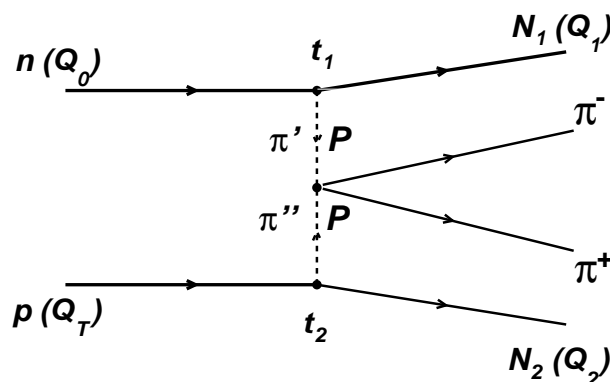


Figure 1: So-called "hanged" diagrams for the reaction $np \rightarrow np\pi^+\pi^-$ including π -meson and pomeron (P) exchanges.

Some exceeding of experimental distribution above the theoretical curve in the effective mass spectrum of $\pi^+\pi^-$ - combinations at $P_0 = 1.73 \text{ GeV}/c$ (Fig.11b in [1]) was considered as a fluctuation at small statistics.

But the data of the reaction $np \rightarrow np\pi^+\pi^-$ at $T_{kin} = 1.25 \text{ GeV}$ [2] (10^7 events) obtained at HADES set-up [3] shown that the bump in the effective mass spectrum of $\pi^+\pi^-$ - combinations is statistically significant and therefore has a dynamic nature. Then it was decided to study the contribution of the "hanged" diagrams into the reaction $np \rightarrow np\pi^+\pi^-$ more detailed.

Let us consider the structure of these "hanged" diagrams.

The matrix element of the "hanged" diagrams being the result of π -meson exchange is written in the following form:

$$T_\pi = G \bar{u}(Q_1) \gamma_5 u(Q_0) \frac{F_\pi(S_{N_1\pi\pi}, t_1, t_2)}{t_1 - m_\pi^2} T_{\pi\pi}(S_{\pi\pi}, t_1, t_2) \frac{F_\pi(S_{N_2\pi\pi}, t_1, t_2)}{t_2 - m_\pi^2} G \bar{u}(Q_2) \gamma_5 u(Q_T) \quad (1)$$

where $\bar{u}(Q_i) \gamma_5 u(Q_j)$ - vertex functions,

F_π - formfactors in the form taken from [1],

$T_{\pi\pi}$ - off shell amplitude of elastic $\pi\pi$ -scattering ([4],[5]),

G the constant of strong interaction ($G^2/4\pi = 14.6$),

$t_1 = (Q_0 - Q_1)^2$,

$t_2 = (Q_T - Q_2)^2$,

$S_{N\pi\pi} = (Q_1 + q_1 + q_2)^2$ and $(Q_2 + q_1 + q_2)^2$,

$S_{\pi\pi} = (q_1 + q_2)^2$.

The corresponding matrix element for the pomeron (P) exchange is written in the form:

$$T_P = g_P(t_1) F_P(S_{N_1\pi\pi}, t_1, t_2) T_{\pi\pi}^{0,0}(S_{\pi\pi}, t_1, t_2) F_P(S_{N_2\pi\pi}, t_1, t_2) g_P(t_2) \quad (2)$$

where $g(t)$ - vertex functions [6],

F_P - formfactors with parameters taken from [6],

$T_{\pi\pi}^{00}$ the S-wave (I=0, L=0) amplitude of elastic $\pi\pi$ -scattering ([4],[5]),

Squared matrix element of the reaction $np \rightarrow np\pi^+\pi^-$ was written in the form:

$$T_h = |T_{\pi^0}|^2 + |T_{\pi^\pm}|^2 + |T_P|^2$$

neglecting the interference of the diagrams for the present.

The results of the calculations for the reactions $np \rightarrow np\pi^+\pi^-$ at $P_0 = 1.73$ GeV/c are shown in Fig.2. One can see that taking into account the "hanged" diagrams permits to get the noticeably better description of the $\pi^+\pi^-$ masses close to 300 MeV/c².

The same calculations were carried out also for the reaction $np \rightarrow np\pi^+\pi^-$ at $T_{kin} = 1.25$ GeV to compare with the data obtained from HADES set-up. The result is presented in Fig.3.

References

- [1] A.P.Jerusalimov et al. Analysis of the Reaction $np \rightarrow np\pi^+\pi^-$ from the Point of View of Oper-Model.
<http://arxiv.org/pdf/1203.3330.pdf>
- [2] A.K.Kurilkin et al. Single and double pion production in np collisions at 1.25 GeV with HADES..
<http://arxiv.org/pdf/1102.1843.pdf>
- [3] P.Salabura et al. HADES Collaboration. NP A749, 150, 2005
- [4] S.D.Protopopescu et al. PR D7, p.1279, 1973.

- [5] D.Cohen. PR D7, p.661, 1973.
- [6] Yu.P.Nikitin and I.L.Rozental. Nuclear Physics of High Energies. Atomizdat, Moscow,1980. (in russian)

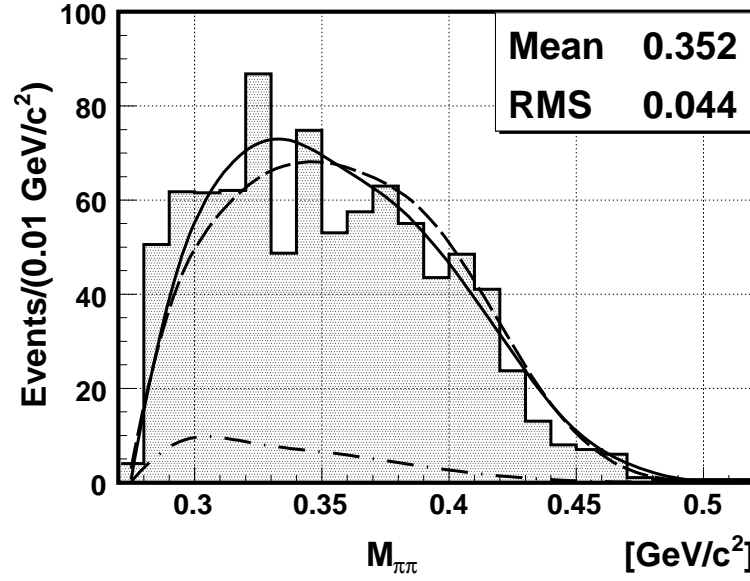


Figure 2: The spectrum of effective masses of $\pi^+\pi^-$ -combinations from the reaction $np \rightarrow np\pi^+\pi^-$ at $P_0 = 1.73$ GeV/c. Solid line - the result of taking into account "hanged" diagrams, dashed line - without "hanged" diagrams, dash-dotted line - the contribution of "hanged" diagrams.

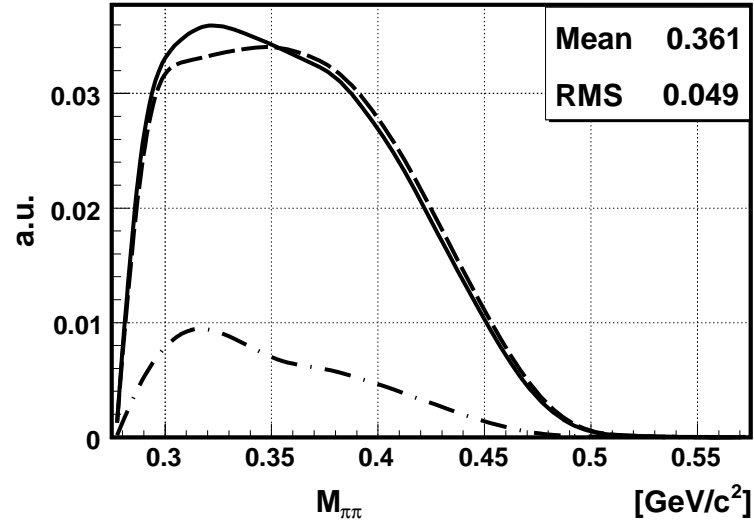


Figure 3: The spectrum of effective masses of $\pi^+\pi^-$ -combinations from the reaction $np \rightarrow np\pi^+\pi^-$ at $T_{kin} = 1.25$ GeV. The notations are the same as in Fig.2.